producing, at any given rate of rotation, the separate tones of a common chord in succession : or by interposing a cylindrical lens to distribute the rays in a linear beam to the four series at once, the united tones of the chord could be produced simultaneously.

Further it was found that the thickness and the breadth of the receiving-disk makes no difference within certain limits in the loudness or quality of the resulting tone. And in the case of transparent substances such as mica and glass these limits may be wide : in the case of glass the loudness was the same with a disk of half a millimetre as with one of three centimetres thickness. In consequence rare substances may be used in disks as small as one square centimetre in area. Cracked or split disks of glass, copper, and aluminium produce sensibly the same effects as if they were whole.

II. *The molecular structure and state of aggregation of the receiving disk appear to exercise no important influence upon the nature of the tones emitted.*—Disks of similar thickness and surface emit sounds of the same pitch no matter of what material they be. Although there may be slight specific differences between the actual modes of production of the phenomenon from *very* thin disks of different materials, these differences are reduced to a vanishing quantity by rendering the receptive surface alike, as for example by covering them all alike with a film of lampblack. Moreover the effect produced by ordinary radiations is, *cæteris paribus*, the same practically for transparent substances as widely differing from one another as glass, mica, selenite, Iceland-spar, and quartz, whether cut parallel or perpendicular to the optic axis, and is the same in polarised light as in ordinary light.

III. *The radiophonic sounds result from a direct action of radiations upon the receiving substances.*—This proposition appears to be established by the following facts :—1. That the loudness of the sounds is directly proportional to the quantity of rays that fall upon the disk. 2. That by using a polarised beam and taking as a receiving-disk a thin slice of some substance which can itself polarise or analyse light, such as a slice of tourmaline, the resulting sounds exhibit variations of loudness corresponding to those of the rays themselves, when either polariser or analyser is turned; and the sound is loudest when the light transmitted by the analysing disk is a minimum.

IV. *The phenomenon appears to be chiefly due to an action on the surface of the receiver.*—The loudness of the emitted sound depends very greatly upon the nature of the surface. Everything that tends to diminish the reflecting power, and increase the absorbing power of the surface, assists the production of the phenomenon. Surfaces that are rough-ground or tarnished with a film of oxidation are therefore preferable. It is also advantageous to cover the receiving surface with black pulverulent deposits, bitumen black, platinum black, or best of all with lampblack; but the increase of sensitiveness under this treatment is only considerable in the case of very thin disks, as for instance from ·1 to ·2 of a millimetre. Very sensitive radiophonic receivers may be thus made with extremely thin disks of zinc, glass, or mica smoked at the surface. It may here be noted amongst M. Mercadier's results that for *opaque* disks, the thinner they are the louder is the sound, and that excellent results are given by metallic foil—copper, aluminium, platinum, and especially zinc—of but ·05 millim thickness. The employment of such sensitive receivers has enabled M. Mercadier to arrive at several other important conclusions

V. *Radiophonic effects are relatively very intense.*—They can be produced not merely with sunlight or electric light, but with the lime-light, and also with gas-light, and even with petroleum flames, and with a spiral of platinum wire heated in the Bunsen-flame.

VI. *Radiophonic effects appear to be produced principally by radiations of great wave-length, or those commonly regarded as calorific.*—In order to satisfy himself on this point M. Mercadier had recourse to the spectrum direct, without attempting to employ cells of absorbant material such as alum solution or iodine in dissolved bisulphide of carbon as ray-filters. A brilliant beam of light was produced by means of a battery of fifty Bunsen cells, and with this, by means of ordinary lenses and a prism of glass a spectrum was produced, the various regions of which could be explored with one of the sensitive receiving-disks mentioned above. The maximum effect was found to be produced by the red rays and by the invisible ultra-red rays. From yellow up to violet, and beyond, no perceptible results were obtained. The experiment was tried several times with receivers of smoked glass, platinised platinum, and plain bare zinc. The greatest effect appeared to be yielded at the limit of the visible red rays. The rays which affect the electric conductivity of selenium in the photophone are, as Prof. W. G. Adams has shown, not the red rays, but rays from the yellow and green-yellow regions of the spectrum. This fact alone would justify the distinction drawn between the phenomena of radiophony and those of the selenium photophone, though probably these are only two of several ways of arriving at a solution of the problem of the transmission of sonorous vibrations by radiation. Theoretically a telephone with a blackened disk inclosed in a high vacuum and connected with an external telephone should serve as a receiver; and the writer of these lines has already attempted to devise a thermo-electric receiver for reproducing sounds from invisible calorific rays.

S. P. T.

THE JOHN DUNCAN FUND

THE following subscriptions to this fund have been received during the past week :—

	£	s.	d.
Amount previously announced	48	6	0
Charles F. Tomes, F.R.S.	1	0	0
J. S.	2	0	0
Dr. Vacher	1	1	0
R. R. Glover	1	1	0
Thomas Walker ...	5	0	0
M. M. Pattison Muir	1	1	0
Major Deedes ...	0	10	0
Anon.	0	1	3
Sir J. Fayrer	1	1	0
T. C. Kent	1	0	0
Lawson Tait	1	1	0
Heinrich Simon ...	2	0	0
	65	2	3

THE TIME OF DAY IN PARIS

THE importance of precise and uniform time throughout Paris becoming ever and continually more appreciated, the Municipality have taken the matter in hand, and have established a system of what they call "horary centres." These horary centres really consist of standard clocks, erected in different places, and controlled by electricity from the Paris Observatory. Moreover each standard clock is furnished with additional electrical work of its own, which enables it to send out an hourly current and control other clocks in its neighbourhood, placed in circuit with it. The advantage of this arrangement over any system of electrical dials is apparent, for with the latter any mischance or practical joke with the wires would cause the whole city to be misled or completely deprived of time. The problem, as put by Leverrier, and as it has been practically solved by M. Breguet, was this :—To keep correct the hour given by various regulators distributed in the city by means of an electric current sent from the Observatory. If the current, in consequence of any accident, fails, the regulators continue to work, with a very slight advance, without the electric correction. The wires have their centre at the Observatory, where there is an astronomical regulator on the first floor. This instrument is maintained at the exact time indicated by the astronomical observations,

by means of an arrangement which obviates the stopping of the pendulum and changing its length. At the bottom of Fig. 1 is a box C, in which may be placed small weights. The weights are of such a shape that it is easy with suitable pincers to put them in or take them out without touching the clock or disturbing anything. The addition of a weight makes the regulator go faster ; its withdrawal retards it. At the upper part of the pendulum is seen the apparatus by which the currents are transmitted ; it is in duplicate, because the pendulum beats seconds, and it is desired to send the current every second. Each apparatus is composed of three identical pieces; three small levers are placed side by side, pivoted at their farthest ends. Their end *i* is raised by the arm V carried by the pendulum at each of its oscillations. During all the time which this contact lasts, the current of a battery passes by the suspension of the pendulum to the arm which carries the three screws and the three levers which conduct it to the line. With a single lever there would be danger of interruptions by a grain of dust ; with three, contact and transmission of the current are absolutely assured. From the Observatory two wires set out ; no use is made of the return earth current. The wires are entirely in the drains, like those of the Telephone Company. Fig. 3 shows these two circuits, each of

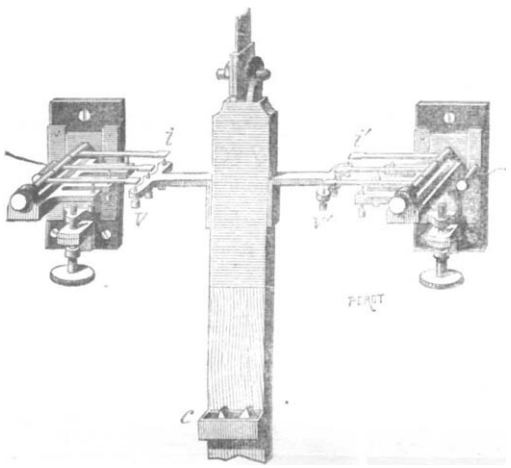

FIG. 1.—Regulator of Paris Observatory.

which is attached to the Observatory by its two extremities. These lines pass by a series of points and traverse the regulators, of which we shall now speak, and which are called horary centres. The pendulum of each regulator (Fig. 2) presents at its lower part a piece of soft iron, which in the oscillations of the pendulum is brought in front of the poles of two electro-magnets in succession. The transmission of the current into these electro-magnets tends to retard a little the movements of the pendulum, and causes each to be perfectly synchronous with that of the Observatory. The regulators of the horary centres show the second ; they are placed in the street, and consequently in view of the passers-by, who may thus compare their watches. Watchmakers may also thus obtain the exact time without making a journey to the Observatory. They are placed in several prominent buildings in various convenient centres.

Why these regulators are called horary centres is explained thus : upon the circuit of horary centres spoken of above, and which the accompanying plan (Fig. 3) indicates by a black line, is grafted another accessory, called the transmission of the hour. Each regulator of the main circuit is itself the centre of a less extensive network of wires, which transmit the hour to the public clocks. For this second service no unique system has been adopted, and uniformity has not been aimed at. Several of the principal watchmakers of Paris, inventors each of a special method of transmitting the hour, are authorised to apply it to the clocks of which they have the care, by borrowing the hour and the current from the nearest horary centre. The most interesting horary centre is that installed at the Hôtel de Ville (at present the Tuileries), and which radiates to the twenty *mairies* of Paris. The city has a telegraphic communication which places the Prefecture of the Seine in connection with the twenty *mairies*. The wires of this system are interrupted about two minutes every hour to place the clock of each *mairie* into agreement with the regulator (horary centre) of the Hôtel de Ville as follows. Beside the regulator are placed twenty relays, into which it sends every hour a current, which cuts off the line from the telegraph ; this commutation is made 100 seconds before the hour. The same regulator, about twelve seconds before the hour, sends the current from a second battery along

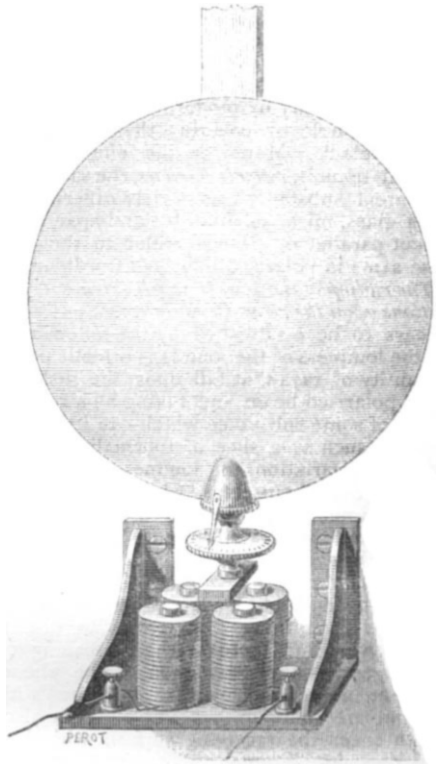

FIG. 2—Regulator of the Horary Centre.

the lines ; it interrupts it at the hour precisely. Ten seconds after the hour the relays are restored to their normal position by the suppression of the first current ; that is to say, the lines are restored to the telegraph.

On the other hand sixty-five seconds before the hour each *mairie* clock makes its commutation, *i.e.* cuts off the line from the telegraph and connects it with the electro-magnet of the clock. And five seconds after the hour it makes the inverse commutation and restores the line to the telegraph five seconds before the resumption of the line by the telegraph at the horary centre of the Tuileries. As the clocks are thus regulated every hour their errors are extremely small. If however a clock gets suddenly out of order or stops, what happens? The current of the horary centre is sent into the telegraph of the *mairie* for thirty seconds continuously ; this abnormal fact announces at once to the telegraphist that the clock is out of order, and he may give orders to have it set right.

In the other horary centres the organisation is less

complicated; it is provided for only six lines, but on each of these may be placed several clocks. The lines are shorter, and radiate only in the quarter which surrounds the horary centre; but they are special to the service of

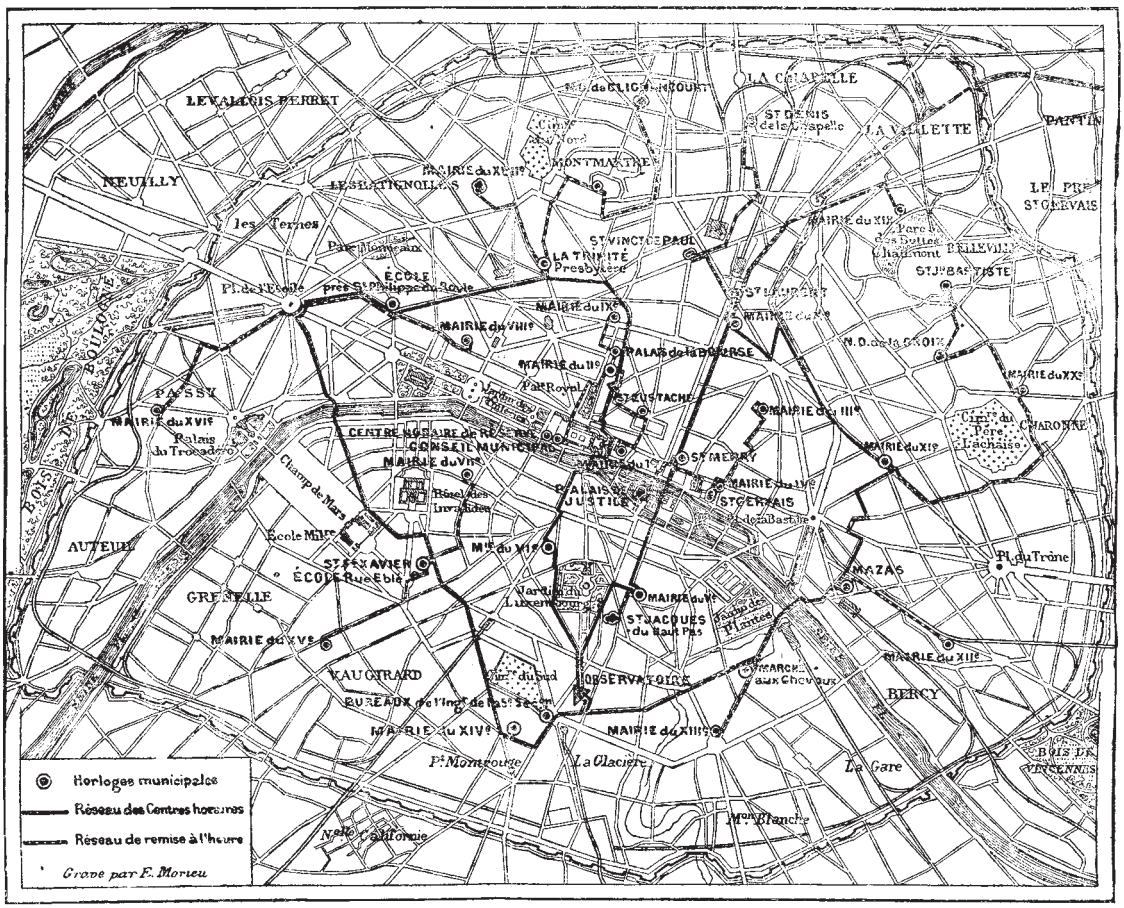

FIG. 3.—Telegraph for the Unification of Time in Paris.

clocks, and are not subject to the complicated operation which is necessary on the circuit of the *mairies*. This service has been organised under the direction of the City Engineers, and does them the highest credit; no doubt it will be gradually developed, so as to include the whole of the *mairies* of Paris.[1]

NOTES

THE honour of knighthood is to be conferred on Dr. James Risdon Bennett, F.R.S., President of the Royal College of Physicians.

M. MARCEL DESPREZ, the well-known electrician, has been created a Knight of the Order of the Legion of Honour.

THE first volume of the U.S. Geological Survey, issued under the headship of Mr. Clarence King, is a magnificent quarto by Prof. O. C. Marsh:—"Odontornithes: a Monograph on the Extinct Toothed Birds of North America"; with thirty-four beautifully executed plates and forty woodcuts. We hope to refer in detail to Prof. Marsh's work very soon.

IN the House of Commons on Tuesday Mr. Shaw-Lefevre said that both the botanical and mineralogical collections have been already removed from the British Museum to the new Museum of Natural History at South Kensington, and are now being arranged there. It is expected that these collections will be open to the public on the next bank holiday—namely, Easter Monday, April 18.

THE Paris Exhibition of Electricity will contain a number of curiosities. M. Salignac will present to the Director-General a plan for cooking by electricity in the grill-room of the restaurant. This plan should provide useful work during the day for the magneto-electric machinery, and test its warming power. M. Michels, an American residing in Paris, has patented a revolving carbon which can be rolled like an ordinary conductor.

WE have now more detailed information about the earthquake which was felt in the Swiss Jura on January 27 at 2h. 18m. p.m. There were two shocks at an interval of five seconds. They were felt especially at Berne, where several chimneys were thrown down, the bell of a church sounded, and the ceiling of a school fell down. At St. Imier the shocks were also rather strong. They were felt also at Neufchâtel, Corcelles, Fontaines, Colombier, Auvernier, and Chaux-de-Fonds to west; at Morges (but not at Lausanne) to south-west; at Solothurn, Basel, and Zürich to north and north-east; and at Signau, Hüttwyl, Berthoud, and Thoune to south and south-east. Two smaller shocks were felt: one on the same day at six o'clock in

[1] From an article in *La Nature*, by M. A. Niaudet.